



**WHAT IS CLAIMED IS:**

[c1] 1. A computer-implemented method of comparing a first free-form surface with a second free-form surface, comprising the steps of:

- (a) extracting surface information from each of the first and second free-form surfaces for determining surface characteristics;
- (b) partitioning each of the first and second free-form surfaces into at least three regions, wherein each region is characterized by a surface characteristic(s);
- (c) for each of the first and the second free-form surfaces, determining the position of each region relative to the other regions;
- (d) comparing regions of the first free-form surface regions with those of the second free-form surface to determine corresponding regions;
- (e) determining at least three pairs of corresponding points from the first and the second free-form surfaces;
- (f) generally localizing the first free-form surface to the second free-form surface ;
- (g) selecting the corresponding points from those corresponding regions;
- (h) fine localization of the first surface to the second surface;
- (i) determining the difference between the points in each pair of the corresponding point sets.

**[c2]** 2. The method of claim 1 wherein the localization of the first free-form surface to the second free-form surface is accomplished by a process consisting of two steps: general localization and fine localization.

**[c3]** 3. The method of claim 2 wherein the general localization is determined based on the corresponding point pairs from the corresponding regions of the first free-form surface and the second free-form surface.

**[c4]** 4. The method of claim 2 wherein the fine localization is accomplished by an iterative process.

**[c5]** 5. The method of claim 1 wherein the comparing of free-form geometries uses high-density point models.

**[c6]** 6. The method of claim 1 wherein the first free-form surface has an arbitrary initial position with respect to the second free-form surface.

**[c7]** 7. The method of claim 1 wherein the first free-form surface is transformed in three translations and three rotations simultaneously.

**[c8]** 8. The method of claim 1 wherein the first free-form surface or the second free-form surface can be either equal or only a portion of another.

[c9] 9. The method of claim 1 wherein the determination of corresponding regions includes comparison of the geometric characteristics including Gaussian curvature, mean curvature, principle curvatures, shape index, shape scale and the regional areas.

[c10] 10. The method of claim 9 wherein the region on the first free-form surface and the region of the second free-form surface having the smallest difference between the selected geometric characteristics are marked as matching regions.

[c11] 11. The method of claim 3 wherein corresponding points for general localization are determined from the relative average center points of the corresponding regions.

[c12] 12. The method of claim 4 wherein corresponding points are determined based on their most similar surface characteristics and closest distances from inside the corresponding regions.

[c13] 13. The method of claim 3 wherein general localization includes the determination of a transformation matrix based on corresponding points using a least square model.

[c14] 14. The method of claim 4 wherein fine localization includes determination of a transformation matrix based on the corresponding points using a least square model with an Iterative Closest Points algorithm.

[c15] 15. The method of claim 13 or 14 wherein the transformation matrix is determined by solving a set of linear equations.

[c16] 16. The method of claim 12 wherein the solutions for determination of the closest points can always be obtained by grid subdivision method.

[c17] 17. A system for comparing a first free-form surface with a second free-form surface, comprising:

- (a) means for extracting surface information from each of the first and second free-form surfaces for determining surface characteristics;
- (b) means for partitioning each of the first and second free-form surfaces into at least three regions, wherein each region is characterized by a surface characteristic(s);
- (c) means for each of the first and the second free-form surfaces, determining the position of each region relative to other regions;
- (d) means for comparing regions of the first free-form surface regions with those of the second free-form surface to determine corresponding regions;
- (e) means for determining at least three pairs of corresponding points from the first and the second free-form surfaces;
- (f) means for generally localizing the first free-form surface to the second free-form surface;
- (g) means for selecting the corresponding points from those corresponding regions;
- (h) means for fine localization of the first surface to the second surface;

- (i) determining the difference between the points in each pair of the corresponding point sets.

[c18] 18. A storage medium encoded with machine-readable computer program code for comparing a first free-form surface with a second free-form surface, the storage medium including instructions for causing a computer system to implement a method comprising the steps of:

- (a) extracting surface information from each of the first and second free-form surfaces for determining surface characteristics;
- (b) partitioning each of the first and second free-form surfaces into at least three regions, wherein each region is characterized by a surface characteristic(s);
- (c) determining the position of each region relative to other regions for each of the first and the second free-form surfaces;
- (d) means for comparing regions of the first free-form surface regions with those of the second free-form surface to determine corresponding regions;
- (e) determining at least three pairs of corresponding points from the first and the second free-form surfaces;
- (f) generally localizing the first free-form surface to the second free-form surface;
- (g) selecting the corresponding points from those corresponding regions;

- (h) fine localizing the first surface to the second surface;
- (i) determining the difference between the points in each pair of the corresponding point sets.